Fuel Choices: The Impact of Alternative Transportation Choices on the Natural Gas and Electricity Markets

The California Advanced Energy Pathways Model

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The Advanced Energy Pathways Project

- **Project was initiated by the California Energy Commission (PIER)**

- **The National Energy Technology Laboratory is supporting LLNL in developing the model**
  - **Effects of vehicles**
  - **Long term effects of climate change on the Western energy system**

- **Our work is done in partnership with**
  - **UC Davis (Joan Ogden, Chris Yang, Ryan McCarthy)**
  - **Global Energy and Technology Foundation (Joe Romm, Peter O'Connor)**

The project will assess the impact of advanced vehicle penetration

- Questions to address
  - How do we make the H2 or provide the electricity for PHEVs?
  - What might the costs be?
  - What are the environmental impacts?
  - How does this impact the balance of the system?
    - Electricity
    - Natural gas
    - Petroleum
  - How does this interact with other state policies (Renewable portfolio standard, Greenhouse gas emissions)

- The AEP model accounts for the detailed interactions between the fuel sectors and the electric sector
  - Hourly patterns of demands and production -> interactions between the fuel sectors and the electric sector
  - Hourly patterns of renewable energy availability (wind and solar) -> high renewable scenarios
  - The effect of storage to buffer production in the system

The analyses will explore some major uncertainties

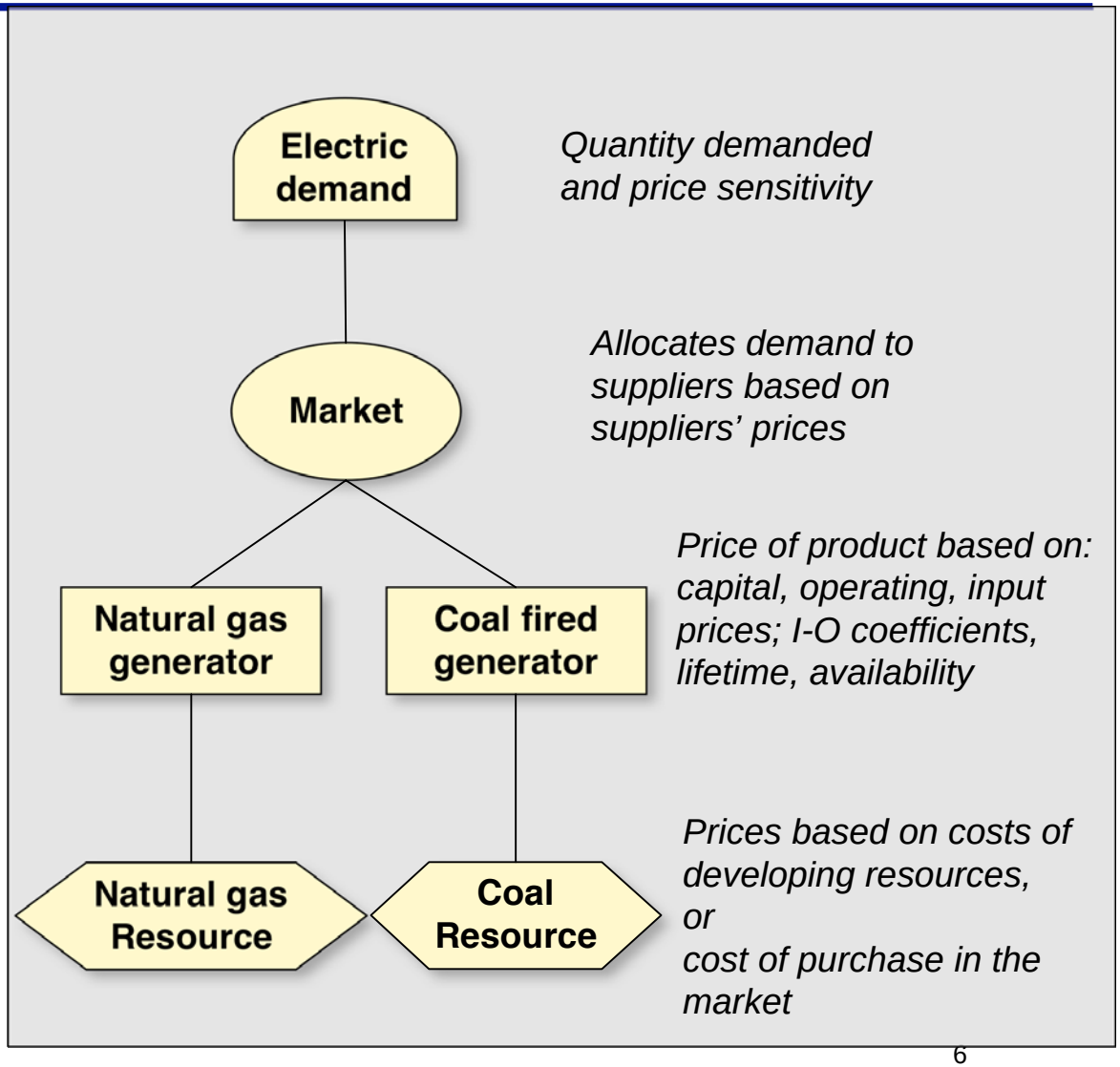
- **Sequestration possibilities**
  - **Raises some regional issues in California**
- **Natural gas prices**
- **Renewable penetration**
- **California economic and demographic growth**
- **Climate change impacts**
- **Response of petroleum and natural gas markets**

Features of the model and analysis

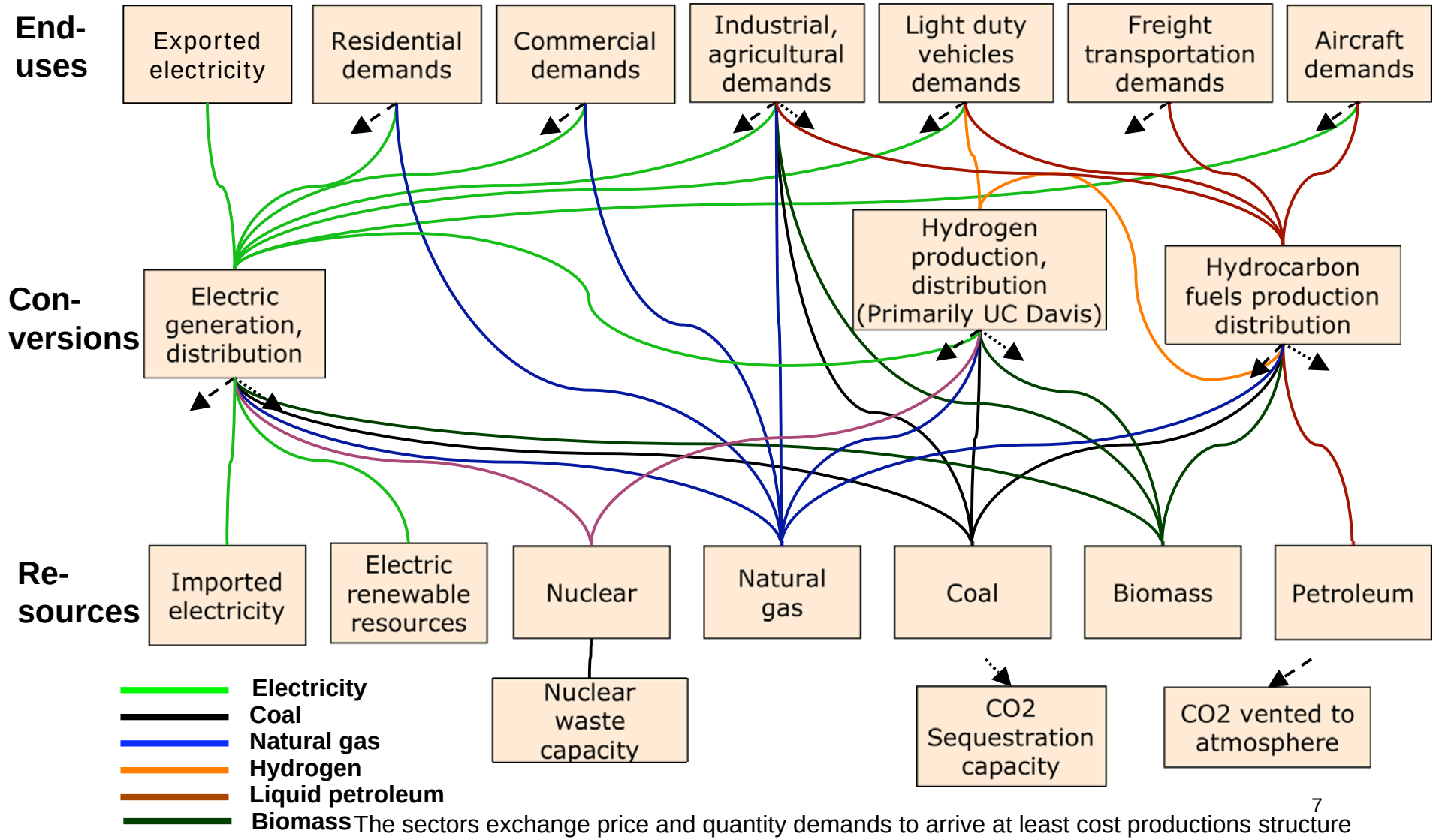
- "Snapshot" analysis: given a set of technology and economic conditions, how would the energy system be organized
  - Provides insight into where we might be going
  - Can use much more detailed models in technology, regional, and time resolutions
- Model structure of system in 2025 and 2050
- Model is driven by scenarios on California population and Gross State Product
  - Gives levels of demand
- Analyses will be done parametrically
  - H2 and PHEV penetration
  - Impact of oil and natural gas prices: at what levels are there significant changes in the system
  - Carbon taxes
  - Availability of sequestration
- We expect that at different levels of taxes, demands, resource prices, and technology characteristics the system will begin to change
  - Uses different resources and technology paths
  - At what levels? What resources and technologies?

Sectoral models represent detailed processes and links between them

- **Based on a "network" view of the system**
- **Each node in the network represents a**
  - **Demand**
  - **Conversion from one form to another**
  - **Resource**
  - **Market**
- **Simulates a market to reach a market equilibrium**
  - **Equivalent to cost minimization**
- **Model finds:**
  - **Demands, given prices**
  - **Allocation of demands among suppliers**
  - **Capacities of conversion processes over time**
  - **Resource development**
  - **Prices at each stage**



Sectors of the California Advanced Energy Pathways model



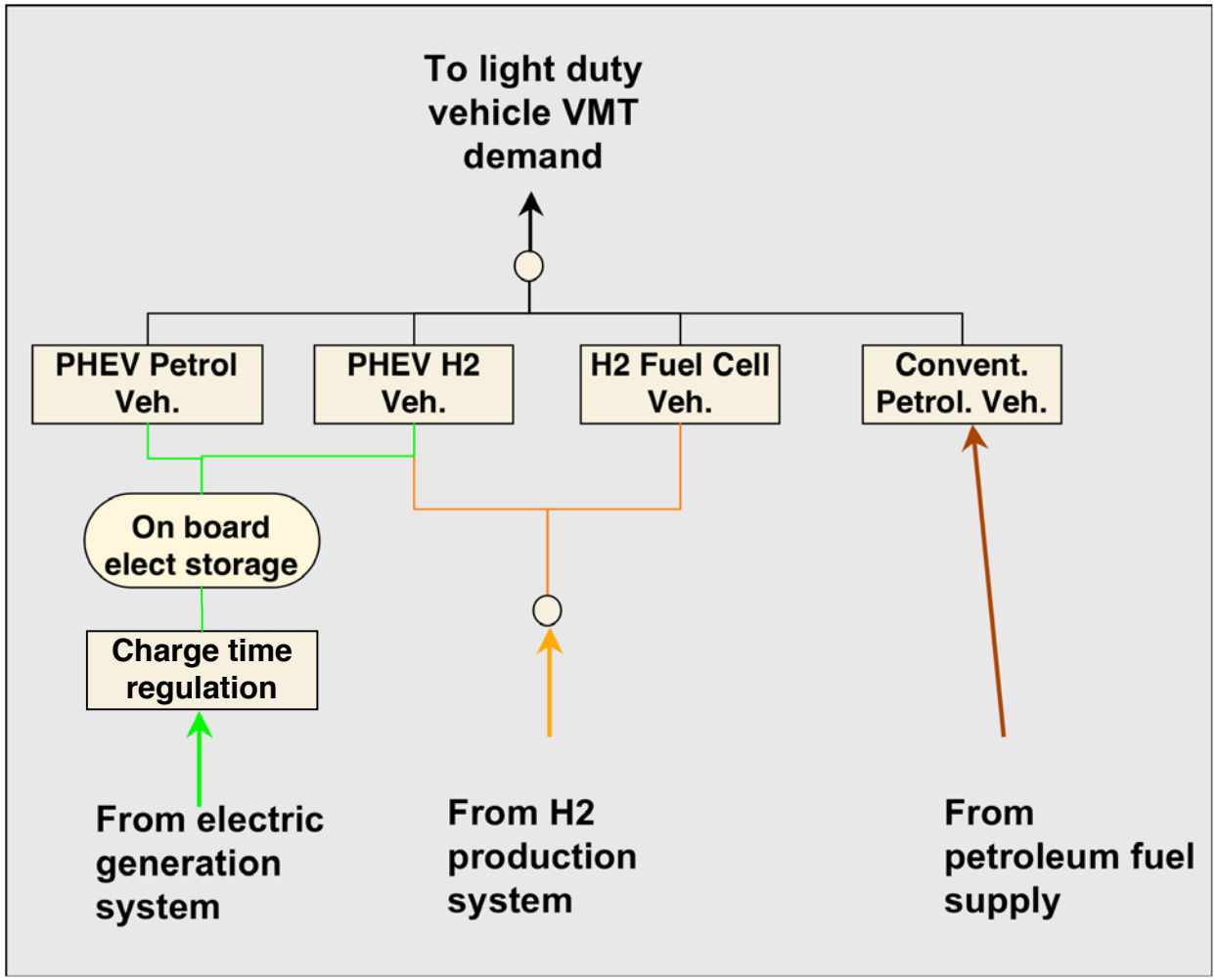
The sectors exchange price and quantity demands to arrive at least cost productions structure

The model is driven by scenarios of energy demand

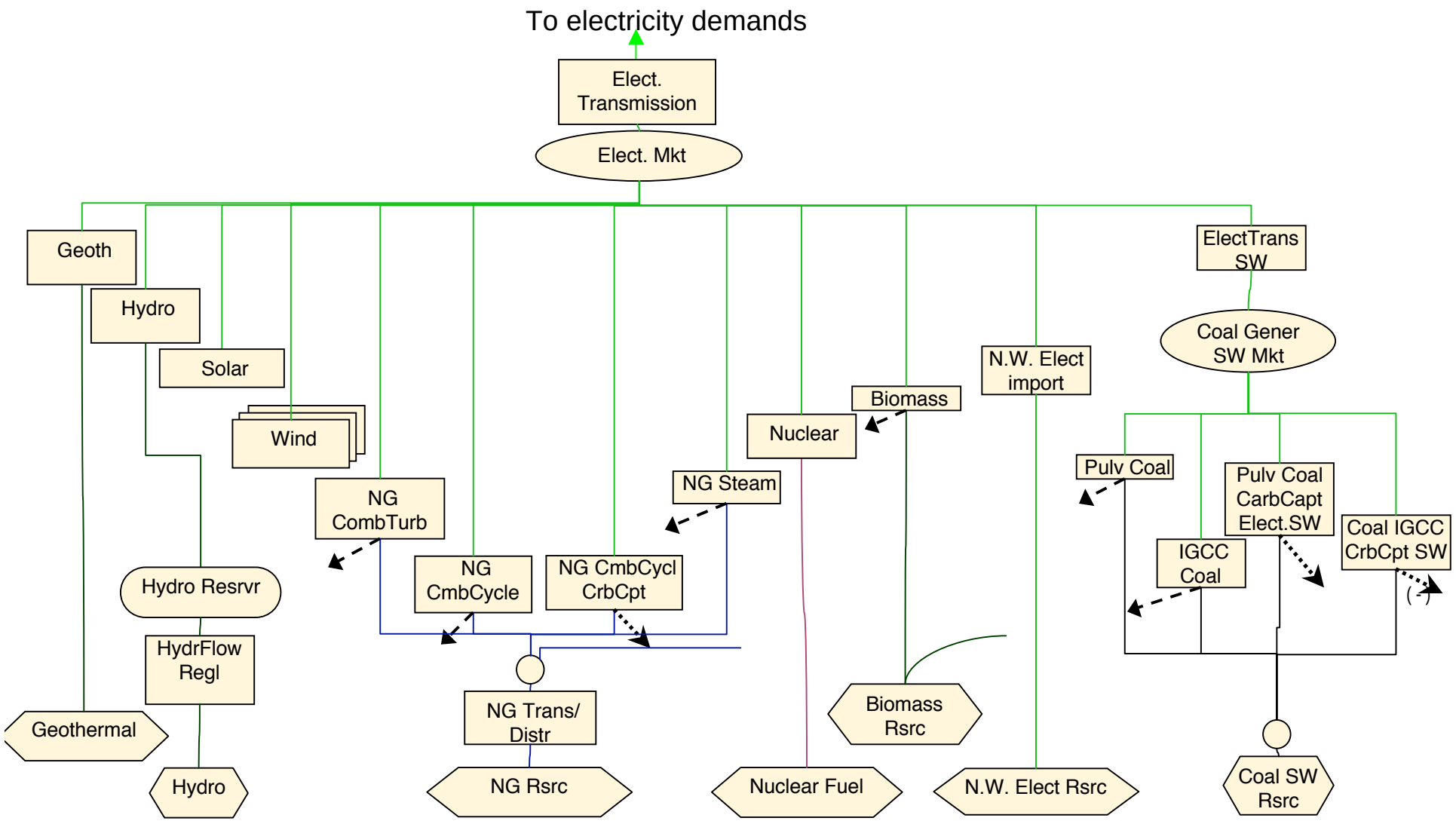
- **Electric and natural gas demands**
  - **Projections of California population, GDP, sectoral growth**
  - **Developing a model to apply CEC approach for appliance penetration and energy use on finer geographic scale**
- **Vehicle characteristics**
  - **UC Davis and GETF**
- **Vehicle penetration**
  - **UC Davis Institute for Transportation studies and GETF**
- **VMT demands**
  - **Largely developed by UC Davis Institute for Transportation Studies**

Technologies in the light duty vehicle sector

- Vehicle shares and demands (quantity, pattern) from UC Davis ITS
- On board storage PHEV electricity allows modeling different charging strategies
  - night, night/day, least cost
- The H2 demand is buffered at fueling stations and production facilities

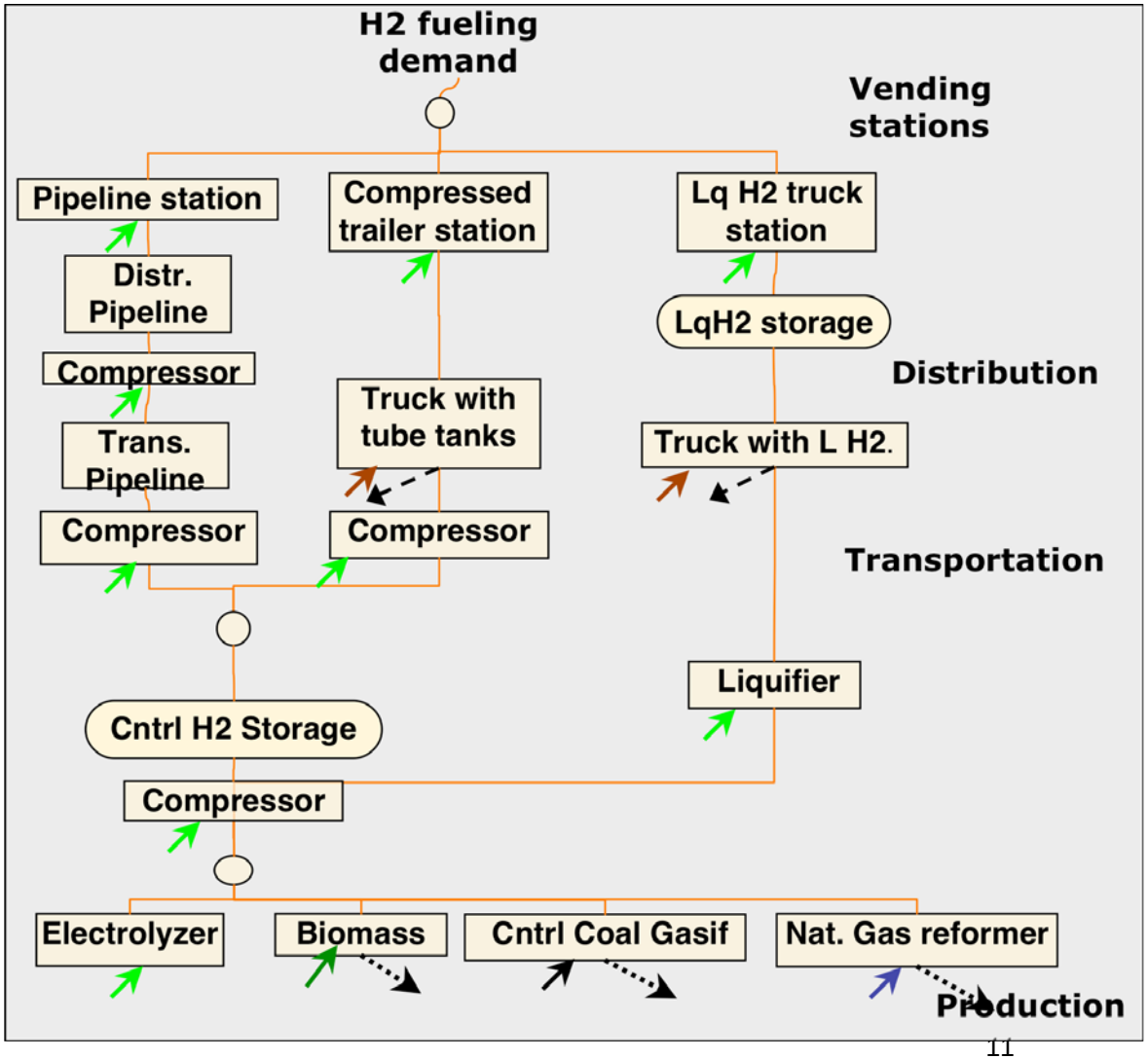


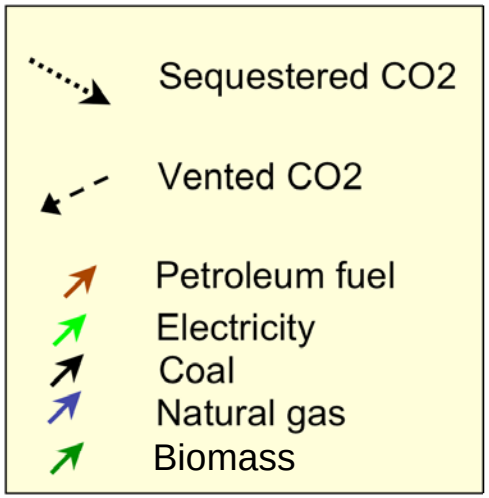
Technology detail in the electric generation sector



The H2 production sector represents several alternative pathways

- High and low density demand regions modeled separately
  - Low density demand regions include local production

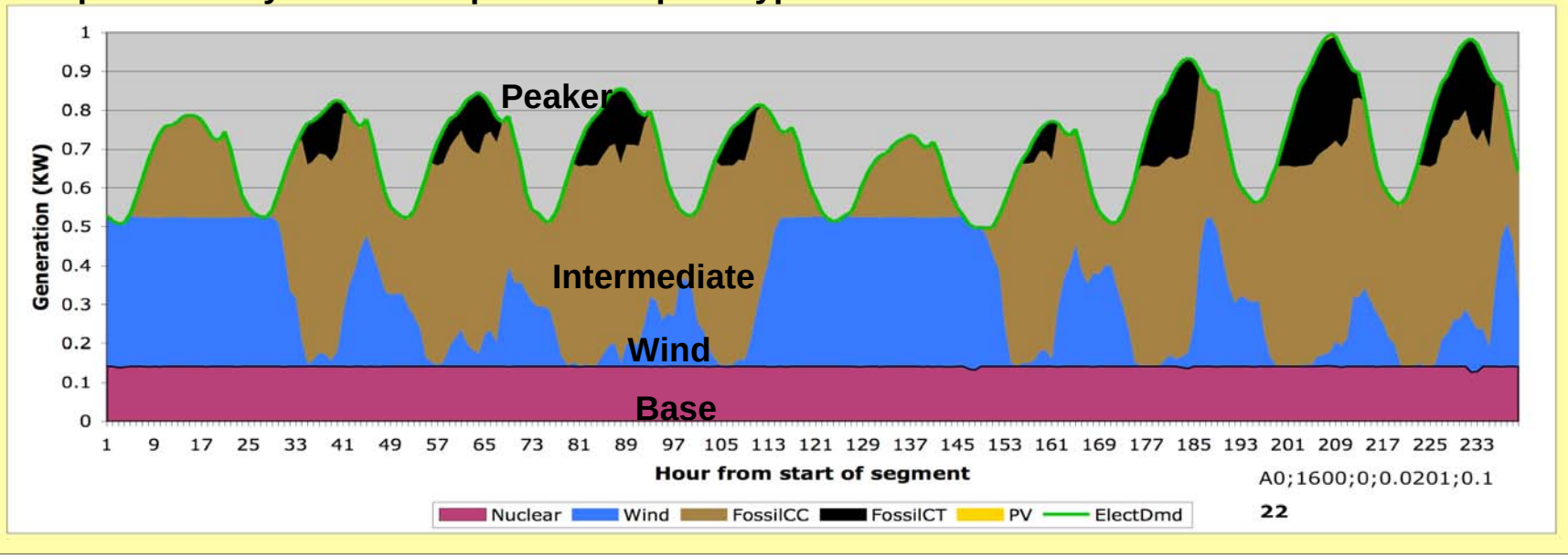




Hourly time resolution allows more realistic assessment of capacities and marginal generation

- **Time detail**
  - Models hour-by-hour over full year
  - Addresses the coincidence in time between demands (from transportation sector and all other sectors), and supply
    - Essential for modeling system with significant penetration of renewables
  - Includes effect of buffering storage at key points in the H2 system
- **Models electric system dispatch and optimal capacities of electric generators, given patterns of demands, and availability**
- **More accurate assessment of the marginal generation**

Example of hourly electric dispatch from prototype model



Regional detail will be added as the model is developed

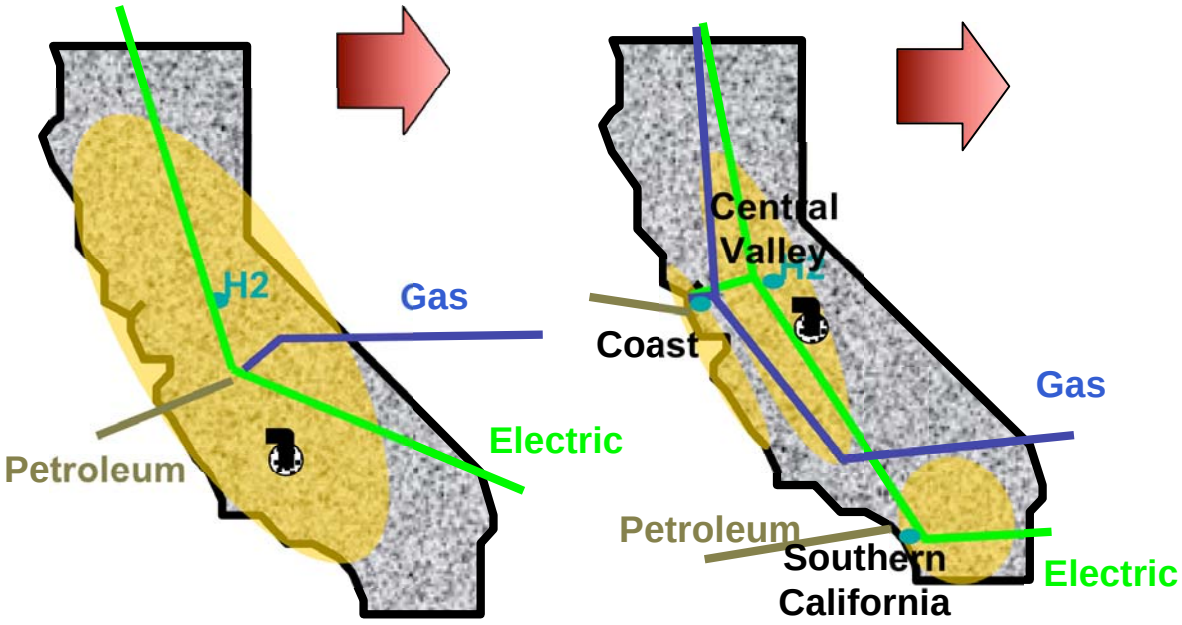
Current model is single region

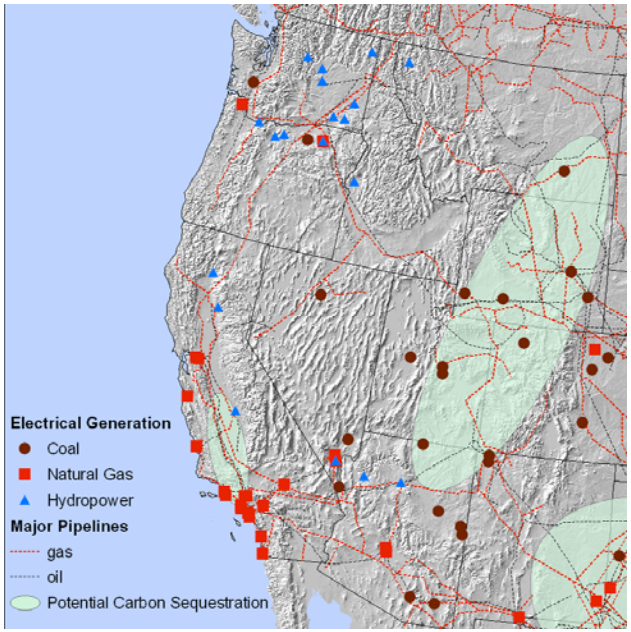
We plan to extend it to a three region model

- captures issues about location of sequestration, transport of CO2 and H2

NETL will extend it to cover the Western US to study

- Measures for carbon control
- Impacts of climate change





Status of data and modeling

- **Data has been developed for most of processes**
  - **Vehicle and H2 production data from UCD and GETF**
  - **Detail for electric, carbon capture, petroleum processes derived from DOE, MIT, EPRI, and CEC sources**
- **Demand scenarios are being developed**
- **Single region version is in process of being commissioned**

Summary

- **The new model will provide a detailed and realistic understanding of the effect of advanced vehicles on the electric power system**
- **Better understand the changes in the system structure**
  - **Types of generators**
  - **Fuels**
  - **Spatial location**
  - **Marginal generation**
  - **Costs**
  - **Emissions**
- **Understand the effects of policies and future development**
  - **Carbon control policies**
  - **Availability of sequestration**
  - **Performance of new technologies**